Hubble Facts

HST Program Office

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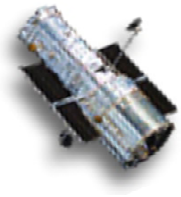


Hubble Space Telescope

GYROSCOPES

The gyroscopes, or gyros, on Hubble are needed for pointing the telescope. They measure attitude when Hubble is changing its pointing from one target (a star or planet, for example) to another, and they help control the telescope's pointing while scientists are observing targets. Three gyros must operate simultaneously to provide enough information to control Hubble. There are a total of six gyros on board--three serve as backups. Each gyroscope is packaged in a Rate Sensor assembly. The Rate Sensors are packaged in pairs, in boxes called Rate Sensor Units (RSUs). It is the RSU that astronauts change when they replace gyros, so gyros are always replaced two at a time.

How do gyros work?

The gyros work by a scientific principal called the ***gyroscopic effect***. This effect can be demonstrated by holding a bicycle wheel by the axle and asking someone to spin the tire. If you try to move the axle of the spinning wheel, you would feel a force in a direction different from the way you were attempting to move it. This force is similar to the way the gyros react when Hubble moves.

The gyroscopic movement is achieved by a wheel inside each gyro that spins at a constant rate of 19,200 rpm on gas bearings. This wheel is mounted in a sealed cylinder, which floats in a thick fluid. Electricity is carried to the motor by thin wires (approximately the size of a human hair) which are immersed in the fluid. Electronics within the gyro detect very small movements of the axis of the wheel and communicate this information to Hubble's central computer.

Why use gas bearing gyros on HST?

There are different types of gyros available. The Mechanical Gyro uses ball bearings instead of gas and works as described above. Other gyros use light or a resonating hemisphere to detect movement. While all these methods can provide information on the movement of the telescope, it is only the gas bearing gyro that can provide extremely low noise with very high stability and resolution. This means that Hubble's gyros are extraordinarily stable and can detect extremely small movements of the telescope. The gas bearing gyros are the most accurate in the world and, combined with other fine pointing devices, keep HST pointing for long periods of time to collect spectacular images of very faint galaxies, planets and stars not visible from Earth.

What is the status of the gyros on HST?

Two of the six gyros on Hubble are not working. Another gyro, while not operating up to its specifications, is still useful. Only three gyros are needed to operate Hubble and take scientific data. Although four of the six gyros are still viable and operational, they are getting "old" and all six will be replaced in the next servicing mission. This would then provide Hubble with six fully operational gyros, increasing the probability of being able to take scientific data until its scheduled decommissioning in 2010.

The HST gyros are the best rate sensing devices available and are critical to Hubble's ability to point and collect scientific data. However, they do wear out and are replaced in 4 to 6 year intervals. Four new gyros were installed during the First Servicing Mission in 1993 and all six gyros were replaced during Servicing Mission 3A in 1999. In Servicing Mission 4, planned for 2005, all six gyros will once again be replaced.

History of HST Gyro Failures

During the last 13 years, gyros have failed because of electronics, failed flex leads, and rotor restrictions. The first two failure modes have been tackled and corrected. Techniques to solve rotor restrictions are being studied.

The failure that prompted the replacement of gyros on the first servicing mission was due to a manufacturing weakness within a hybrid electrical component. All gyros since then have contained a more robust hybrid made by a different manufacturer.

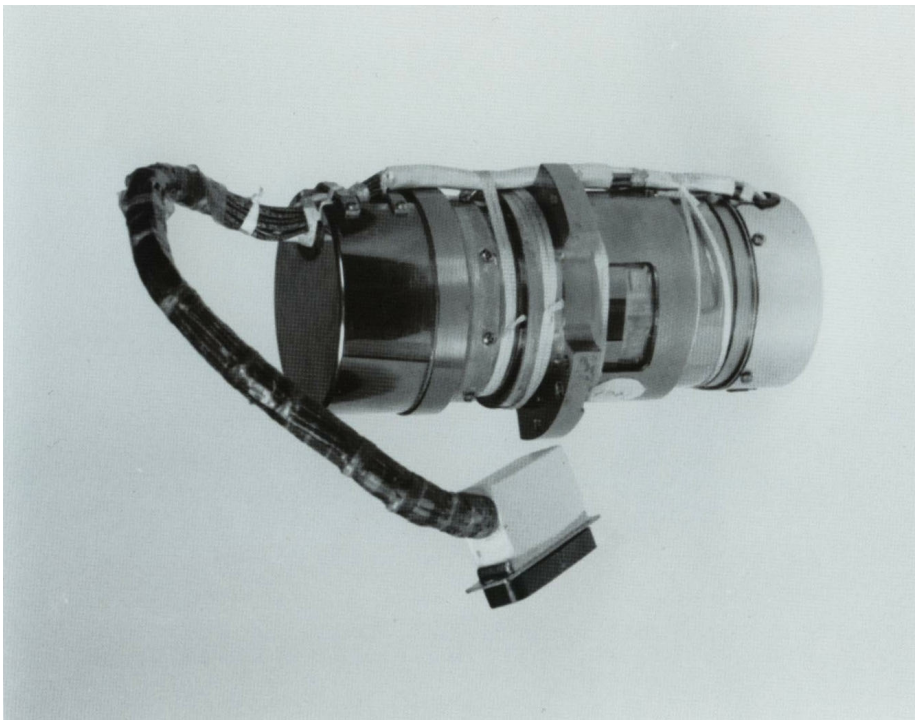
The second failure mode, the flex lead failure has been solved by removing the oxygen from the fluid fill process and by protecting the flex leads from corrosion by plating them with silver. Just three of the six gyros installed in SM4 will have these enhanced (plated) flex leads because this plating process only became available after the first three gyros for the mission were built.

The Hubble team believes they understand the cause of the current on-orbit gyro failures, although they cannot be certain until the gyros are returned from space and taken apart. Based on many years experience in building gyros, the team believes that a "rotor restriction" has occurred. A rotor restriction is either due to a patch of lubricant that has built up in the air bearing of the gyro motor or a small particle that has found its way between the bearing surfaces. This "rotor restriction" prevents the air bearing from turning smoothly and the motor cannot run properly. Extensive testing is done during the build of a gyro to detect if it is prone to a rotor restriction, however, a very small percentage of gyros pass this testing and then fail later. These are the first HST gyros to fail on-orbit due to rotor restrictions.

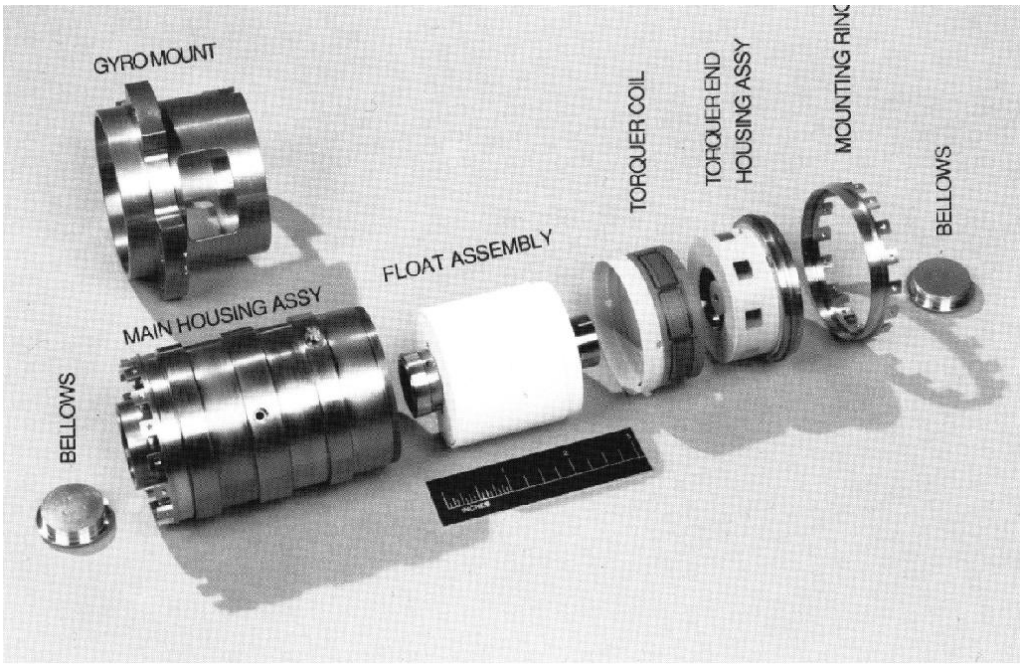
The HST Project is presently investigating the use of Diamond-Like Coating on the bearing surfaces of the gyro to address the problem of rotor restrictions. This is the same coating that has allowed a tiny turbine within the NICMOS Cyrocooler to surpass 400 billion revolutions.

RATE SENSOR UNIT CHARACTERISTICS
(Each unit contains two gyros)

Size: 12.8 x 10.5 x 8.9 inches
Weight: 24.3 pounds



Rate Sensor



Gyro Exploded View